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(Last name) (First name) (Middle name) Score _____

When is your birthday? _____ Age last birthday _____ Yrs.

Age _____ Yrs. _____ Mo. _____ Da. Class in school _____
(Do not fill in) (Freshman, Jun., etc.)

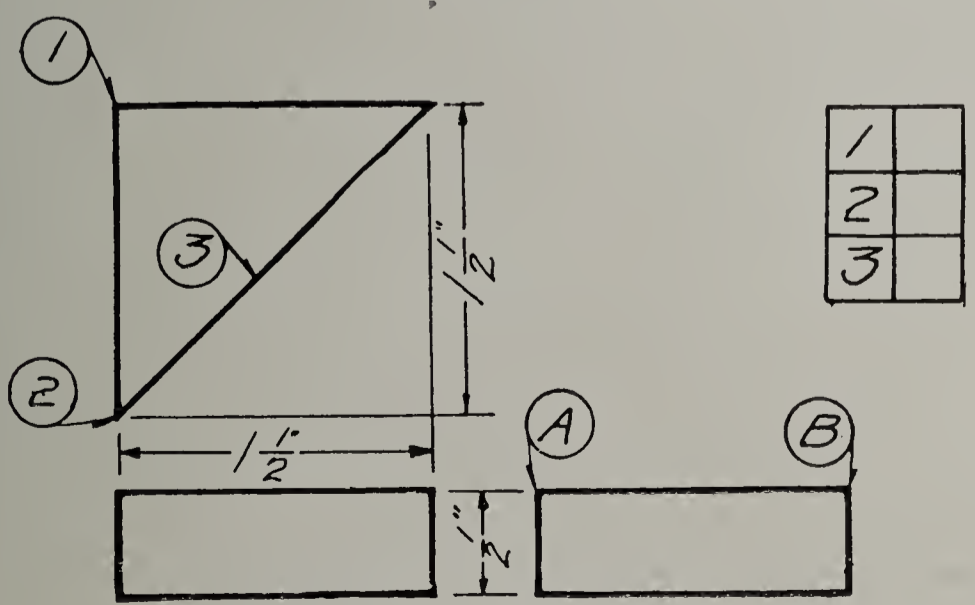
How many months of drawing instruction have you had? _____

MECHANICAL DRAWING TEST
for
HIGH SCHOOLS, TRADE, AND TECHNICAL SCHOOLS
by
DREW W. CASTLE
Vocational Director
Joliet Township High School and Junior College
Joliet, Illinois

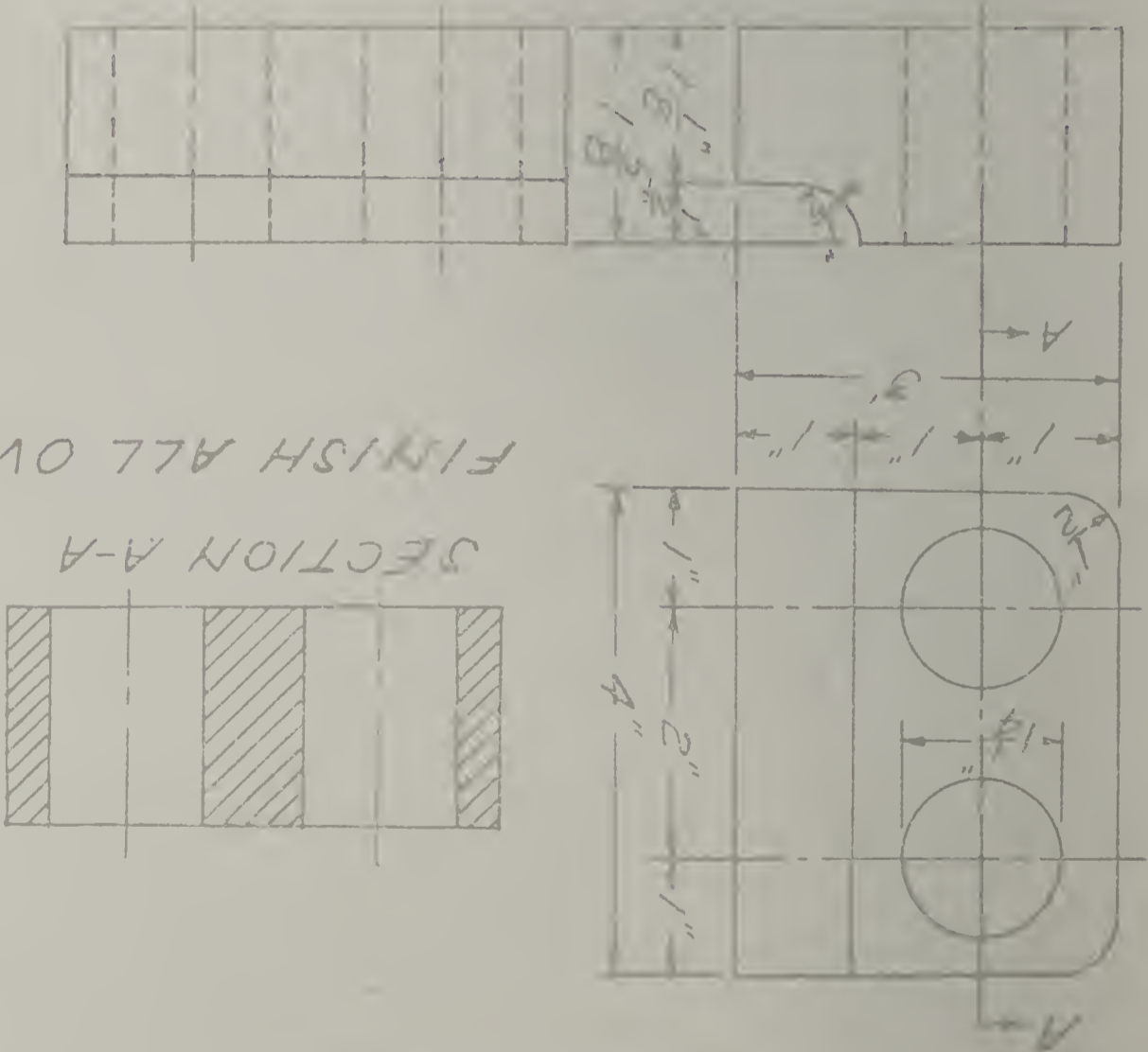
INSTRUCTIONS FOR PART No. 1 (a, b, and c)

Notice the numbers in the circles on the top view. Notice that these numbers are repeated in the left-hand column of squares. In the circles on the side view are letters. After a careful study of the drawing it will be further noticed that certain numbers on the top view and certain letters on the side view point to the same part of the object. Place these letters opposite their corresponding numbers in the right-hand column of squares. The top view has one more circle than the side view. Consequently, one circle on the top view has no corresponding circle on the side view. The number in that circle is to have a blank space opposite it in the right-hand column of squares.

SAMPLE



INKING TECHNIC



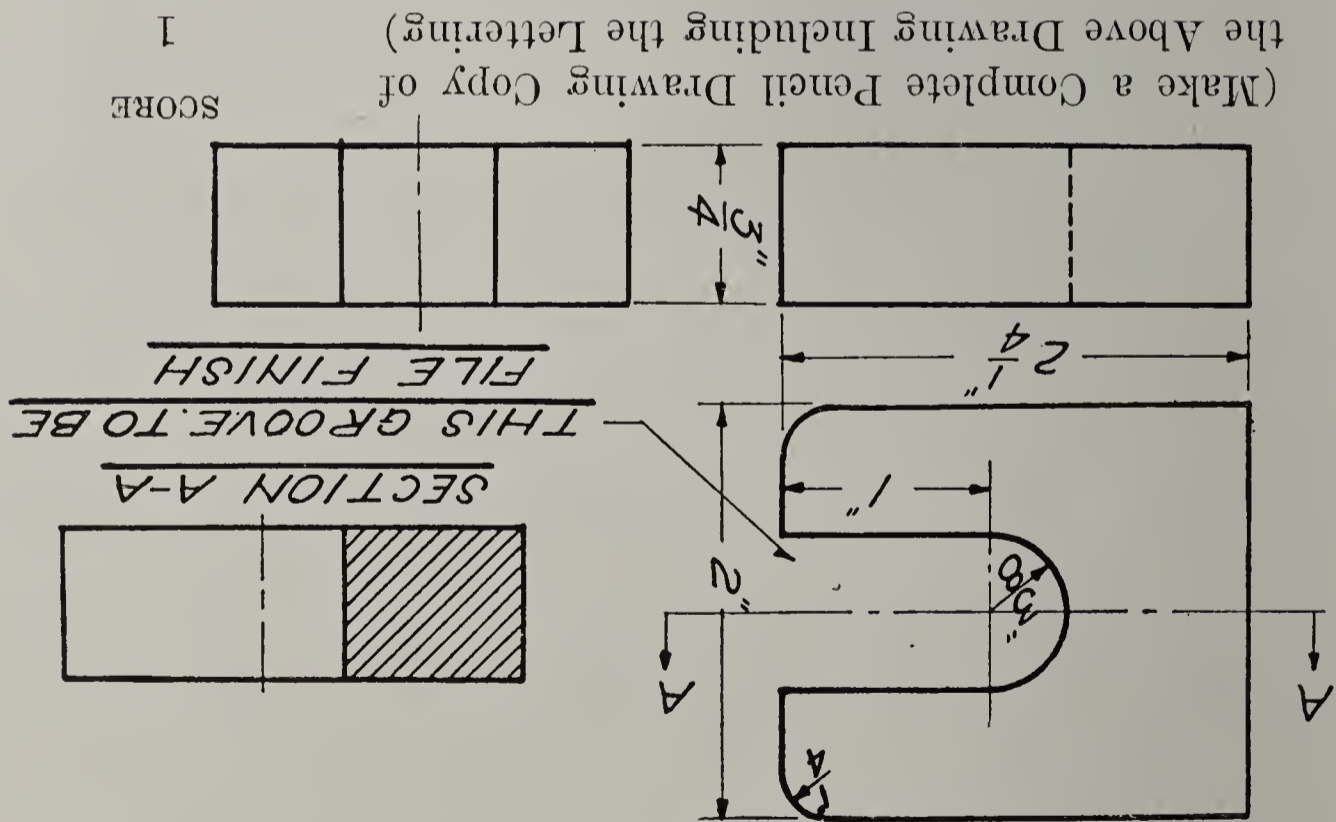
(Use This Space for
Testing Your Pen)

SCORE
1
2
3
4
5
6

TOTAL

POSS. SCORE		1. INTERPRETATION BY FEATURES	28
SCORE		2. DIMENSIONS	6
		3. GEOMETRICAL TERMS	14
		4. PENCIL TECHNIC	26
		5. INKING TECHNIC	26
		TOTAL	100

PENCIL TECHNIC



(Make a Complete Pencil Drawing Copy of the Above Drawing Including the Lettering)

SCORE

1

2

3

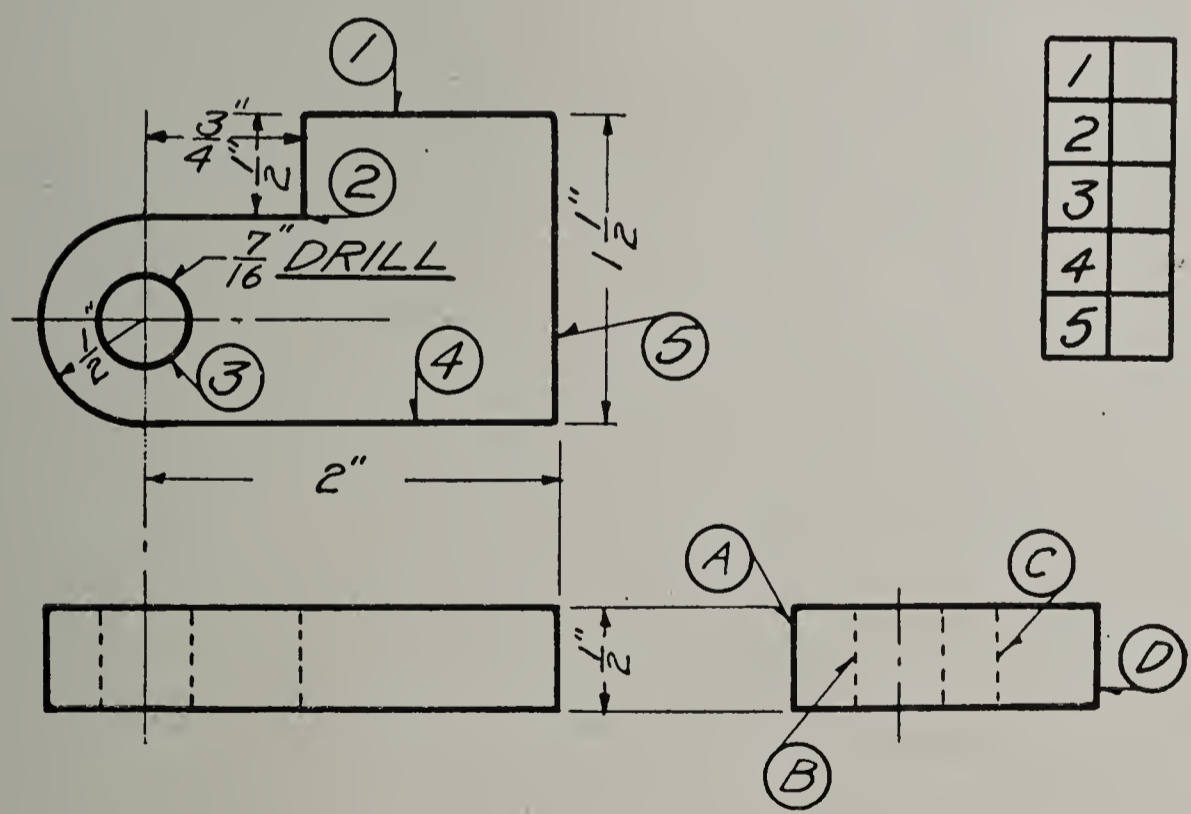
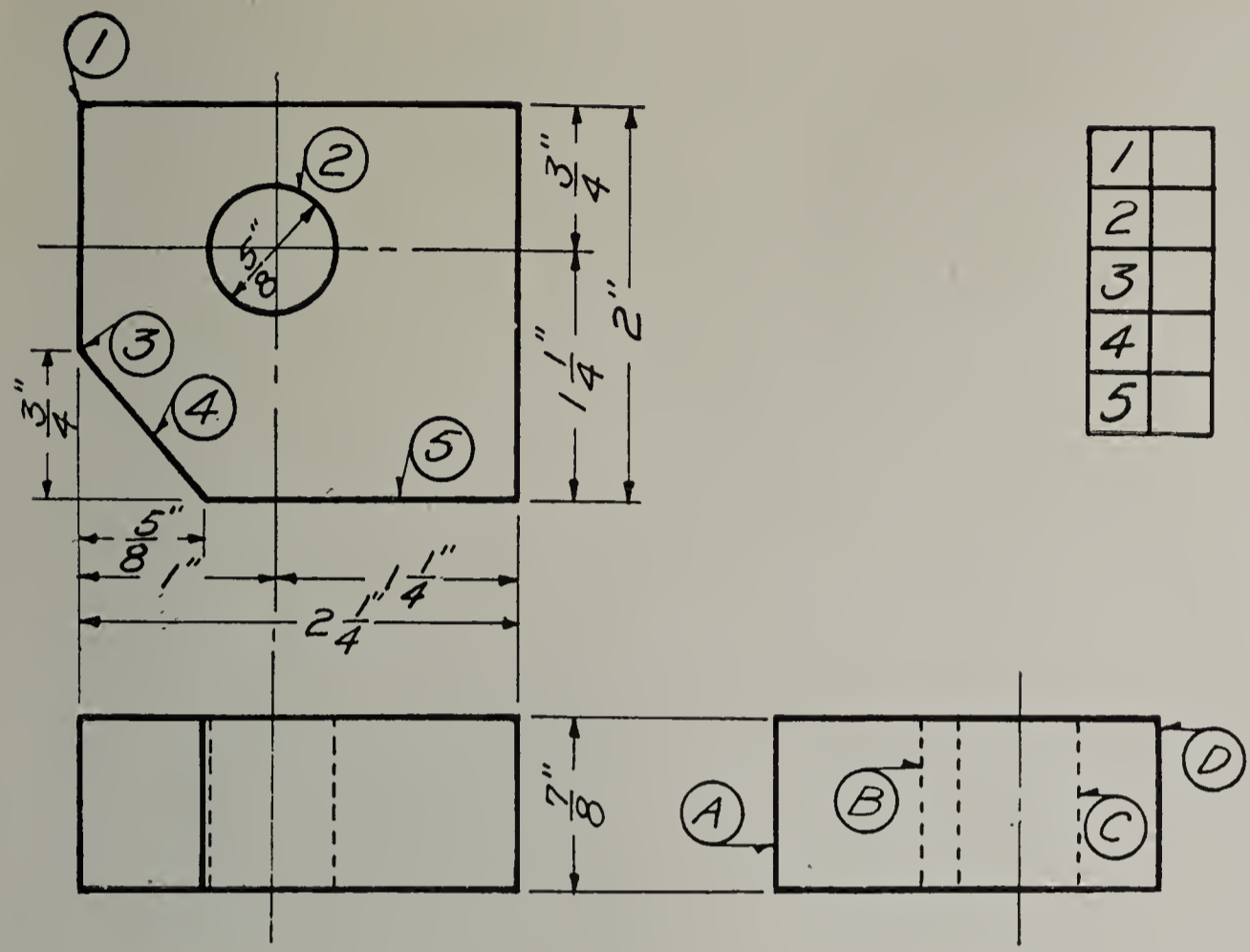
4

5

6

TOTAL

INTERPRETATIONS BY FEATURES



Turn This Page When You Are Through

TOTAL _____

GEOMETRICAL TERMS

Underline the word that applies

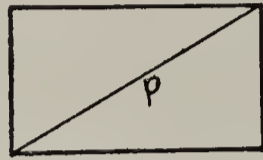
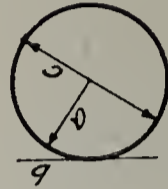
(Sample)

Coins are :

Round, Square
Long, Rectangular

1. Telephone wires are : Angle, Vertical, Square, Parallel
2. To each other a telephone pole and wires are : Obtuse, Vertical, Perpendicular, Opposite
3. A floor is : Oval, Horizontal, Rectangular, Acute
4. An orange is shaped like a : Cube, Cylinder, Sphere, Pyramid
5. A lamp cord hangs : Perpendicular, Angle, Vertical, Round
6. A church steeple is shaped like a : Cone, Cube, Pyramid, Line
7. The open legs of a compass form an : Oblong, Angle, Ellipse, Acute
8. The top of a table is a : Pyramid, Square, Surface, Vertical
9. A tin cup is shaped like a : Triangle, Cone, Cylinder, Circle
10. The edge of a rule is : Sharp, Straight, Long, Triangle

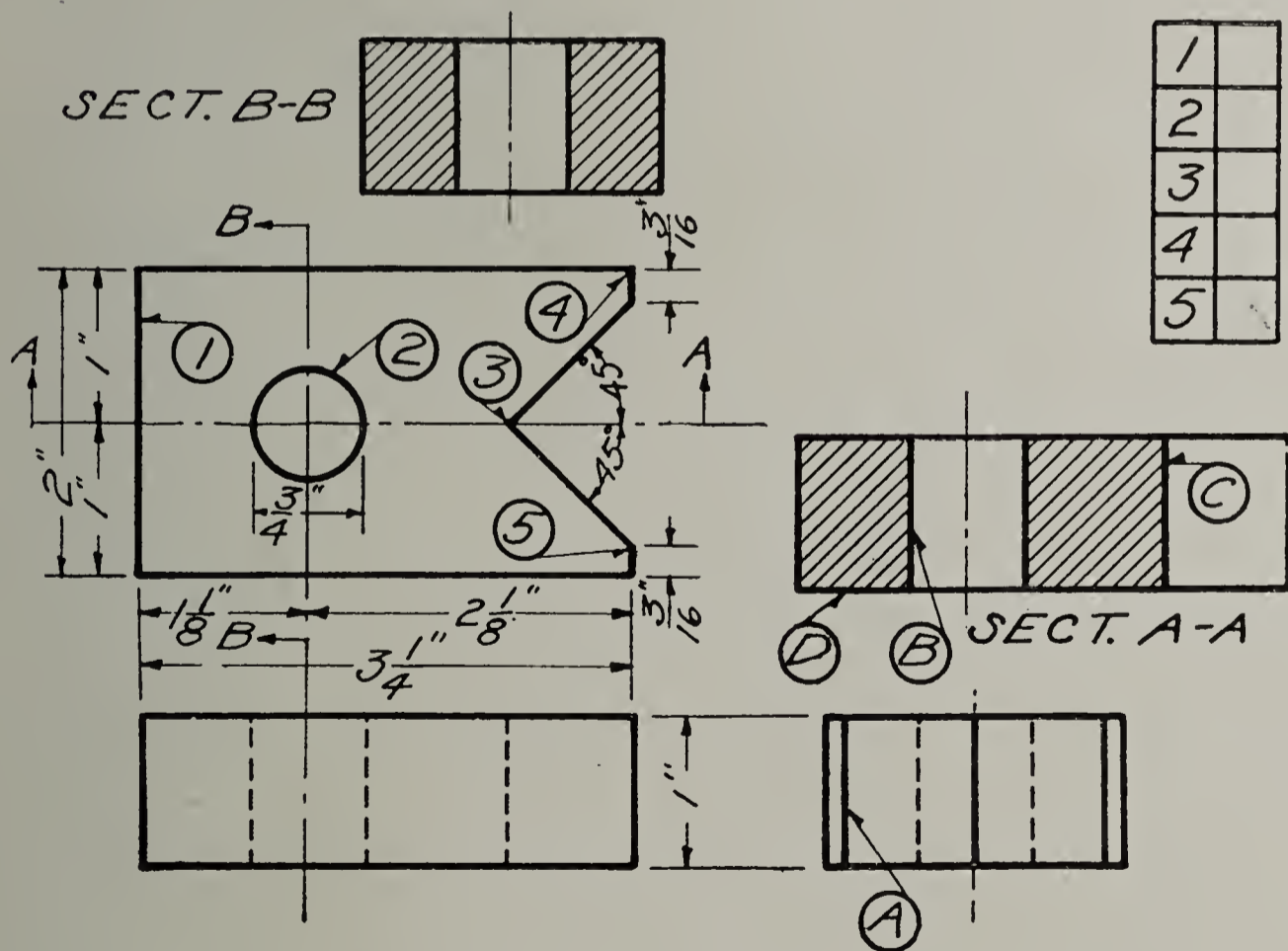
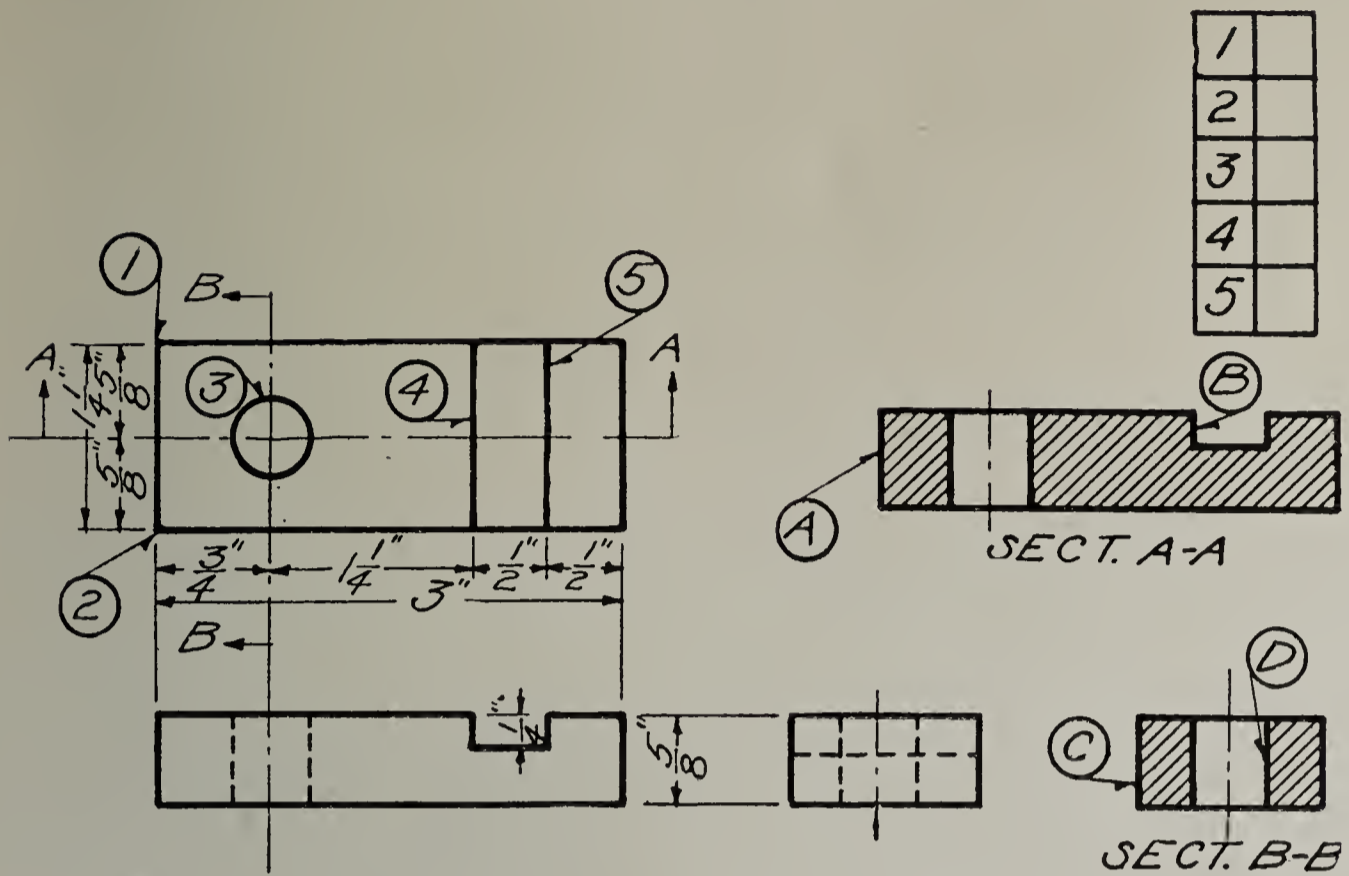
11. The line *a* is called the _____ of the circle.
12. The line *b* is _____ to the circle.
13. The line *c* is called the _____ of the circle.
14. The line *d* is called the _____ of the rectangle.



Fill in the appropriate word

Total

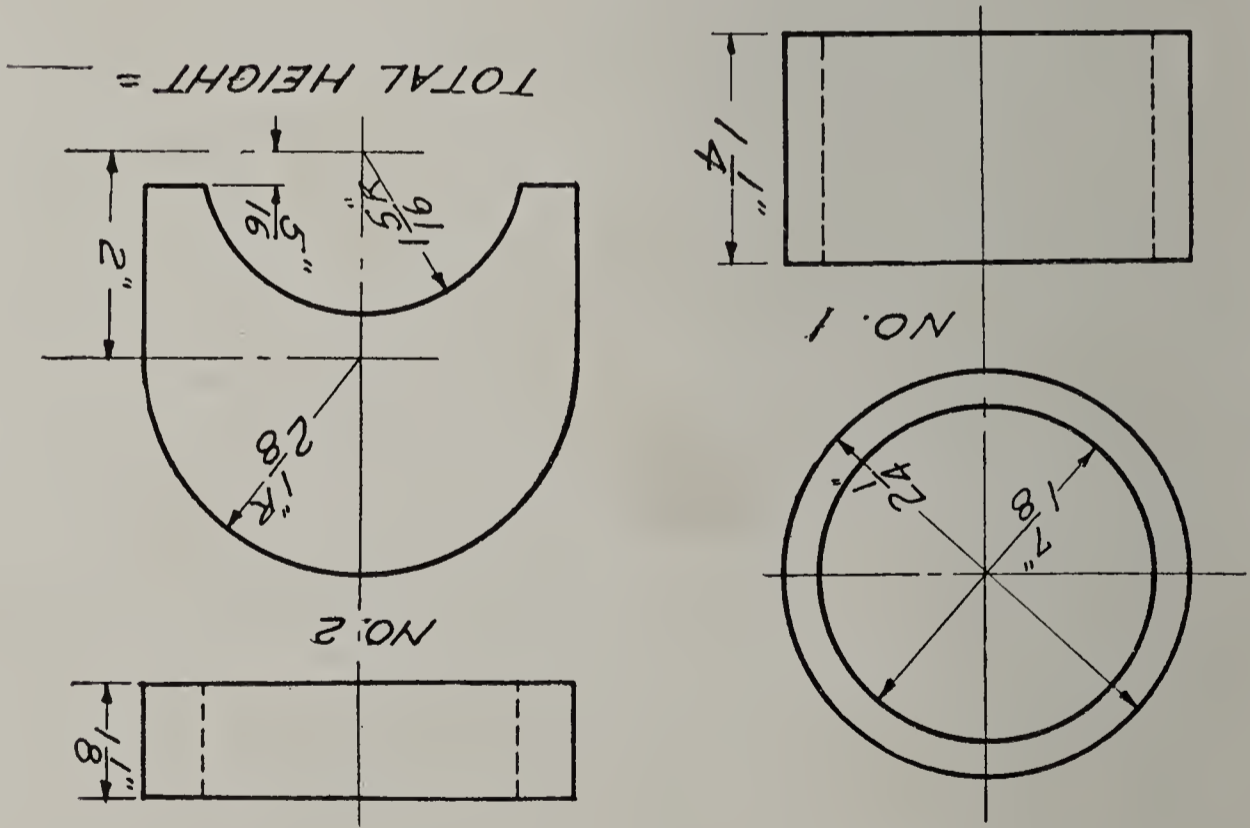
INTERPRETATION BY FEATURES



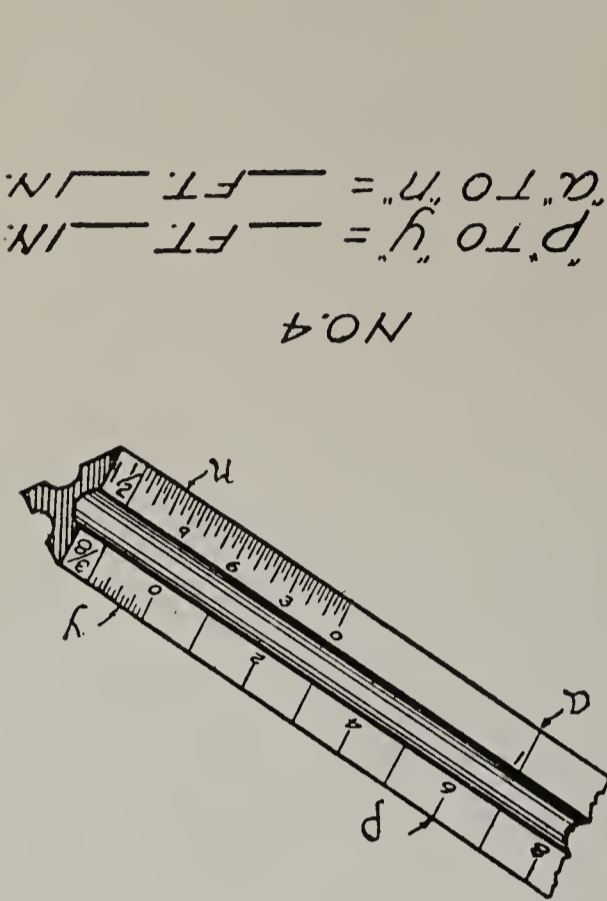
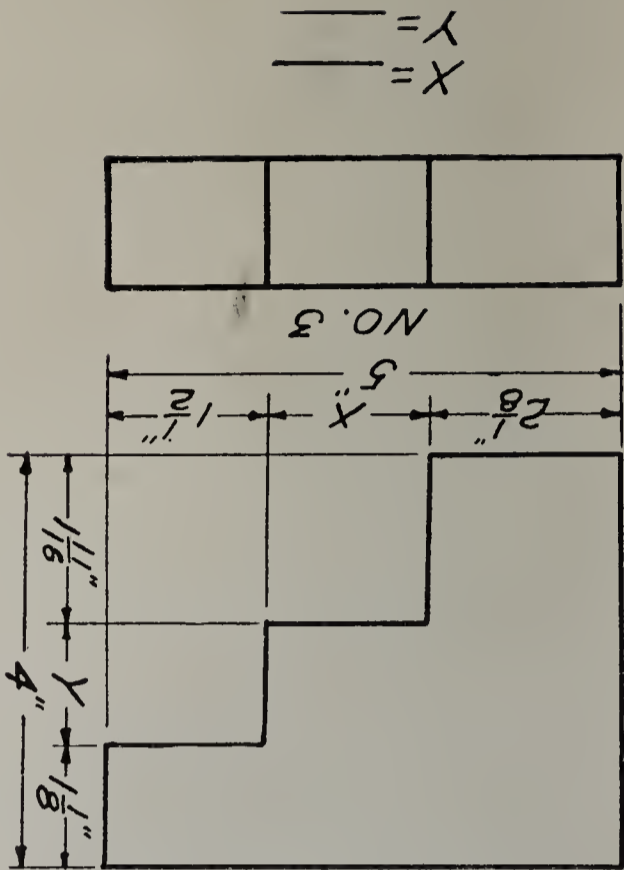
TOTAL _____

DIMENSIONS

On the Lines Below, Opposite the Equality Marks,
Insert the Dimensions Asked for



THICKNESS OF WALLS =



TOTAL

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27.2

Manual for Mechanical Drawing Test

By

D. W. CASTLE

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Joliet Township High School and Junior College

Joliet, Illinois

IN designing a test in any subject it is first necessary to analyze the field to determine the various units of subject matter or achievements to be tested. Agreement in this matter is seldom possible, for local conditions alter educational demands. It is almost always possible, however, to pick out the most prevalent units of a subject by studying many representative courses of study in the subject from progressive schools. This has been done with the result that mechanical drawing was analyzed into the following divisions:

1. Interpretation of drawings of objects by their features.
2. Use of arithmetic in mechanical drawing dimensional situations.
3. Use of geometrical terms.
4. Pencil drawing technic.
5. Inking technic.

The problem that presented itself after the analysis was decided upon was the choice of various devices and methods that would test adequately the abilities in these units of the subject, each independent from the other; independent from one another, because without the quality of independence obtained from each individual part there is no assurance that the measures of a test are not also measures in some degree of other abilities obtained from other parts of the test. Lacking the quality of measuring, isolated, each ability, a test cannot be used with much confidence for diagnosing pupil difficulties, and a test

that cannot be used in this way is of little value to the teacher in the schoolroom or shop.

A great deal of care must be exercised in the selection of the devices for measuring the ability of a pupil to interpret a drawing. Requiring the pupil to make, with his own hands, some object conventionally represented by a drawing would, of course, be the most natural and best possible device for measuring this ability. The impracticability of following this procedure in a test is obvious. Requiring the pupil to draw the conventional views of an object is likewise undesirable, because a measure from this procedure would also include a measure of his drawing technic. Furthermore, we have no assurance that the ability to draw an object in mechanical drawing conventions and the ability to read a conventionalized mechanical drawing made by someone else are identical. The device that is used for this purpose in Part No. 1 is based upon the psychology of the association of the elements of a conventionalized mechanical drawing representation of an object, a mental process that is used in reading drawings.

PART NO. 1. INTERPRETATION OF DRAWINGS

It is hardly possible to associate with certainty an element (solid, dotted, or center lines) of a view directly with the corresponding fea-

ture on the object without associating that element with other elements on other views, all of them representing the same features.

This psychology may be illustrated

columns of squares, those numbers and letters which point to elements on the drawing that represent the same feature on the object. (See the sample problem on the front of test.)

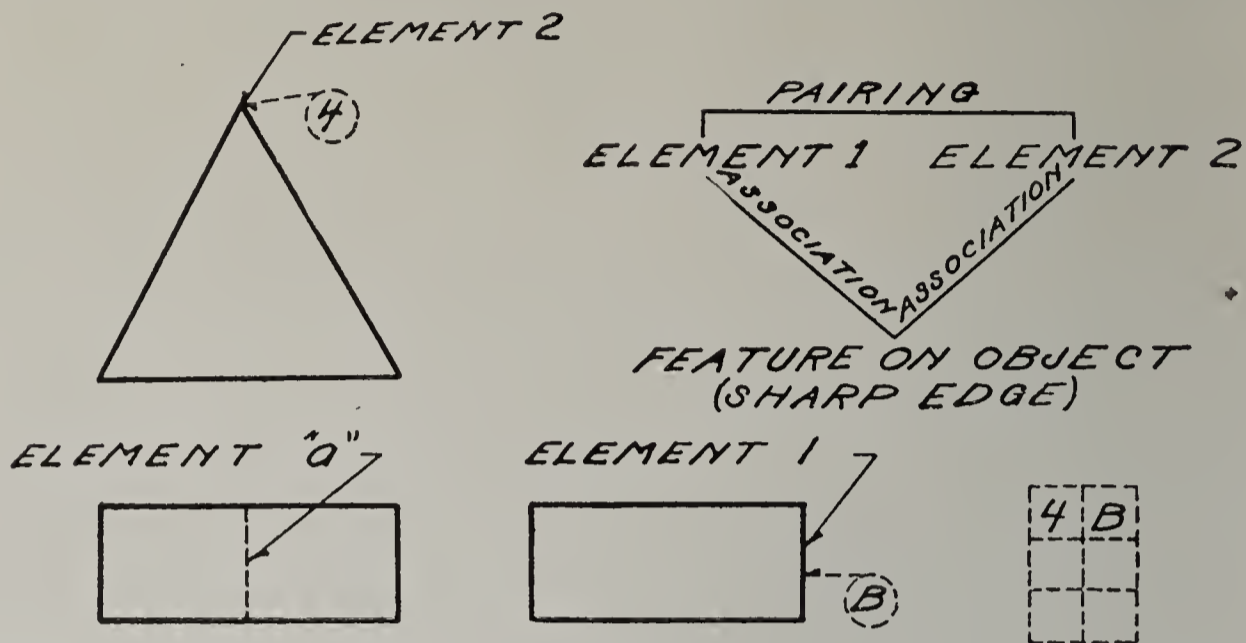


FIG. 1

by Fig. 1. If the reader of this drawing were to look at Element 1 he would associate it with a flat surface, an edge, or the tangent line of a cylinder. If, however, he were to shift his attention from Element 1 to Element 2, he would be able to associate Element 1 with Element 2 and recognize at once that the feature on the object which both of these elements represent is a sharp edge. As a check on this interpretation, the attention may be shifted to Element "a" where it would be recognized that the dotted line represents a hidden corner.

Now, if it is desired to test the ability of the reader of this drawing to recognize that these features represent a sharp, hidden edge, it is only necessary to require him to demonstrate that he has associated Element 1 with Element 2. The device that is used for this purpose is a system of circles in which the subject inserts numbers and letters and pairs in

As the triangle diagram in Fig. 1 indicates, if the subject has made the proper associations between Element 1 and the feature it represents and Element 2 and the same feature, he will be able to indicate this fact by pairing the letter in the circle that points to Element 1 with the figure in the circle that points to Element 2 through the proper record in the squares. If the subject does not make the proper record in the columns of squares, it indicates that he is not able to analyze and interpret these elements of the drawing.

The occasion might arise where it will be necessary to associate an element on one view with more than one element on another view before a correct interpretation of them can be made. This situation may be illustrated by Fig. 2.

Element 1, at a casual glance, might be associated with a hole, but it is possible for such a line to represent

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a projection instead of a depression. However, if Element 1 is associated with Element 2 and in addition a further association is made with Element 3, one recognizes at once that the feature represented by all three of them is a hole, because Element 2 and Element 3 are dotted lines extending from the top of the object to the bottom. In the case of this drawing, Elements "a" and "b" serve as a check.

The fact that the subject, in a problem such as this one, finds it necessary to make a second association, as Element 1 with Element 3, before he is sure that Element 1 and Element 2

are in general directly to the right of their corresponding elements in the front view. Because of this fact it is possible to pair corresponding elements in these views by their position only, a situation that would invalidate a test if such responses were required.

PART NO. 2. DIMENSIONS

In Part No. 2 the problem of eliminating the measure of the interpretation ability so that the ability to solve dimensional problems in mechanical drawing only could be measured, was the most important one to solve. This apparently could only be done by making the drawings as simple as possible,

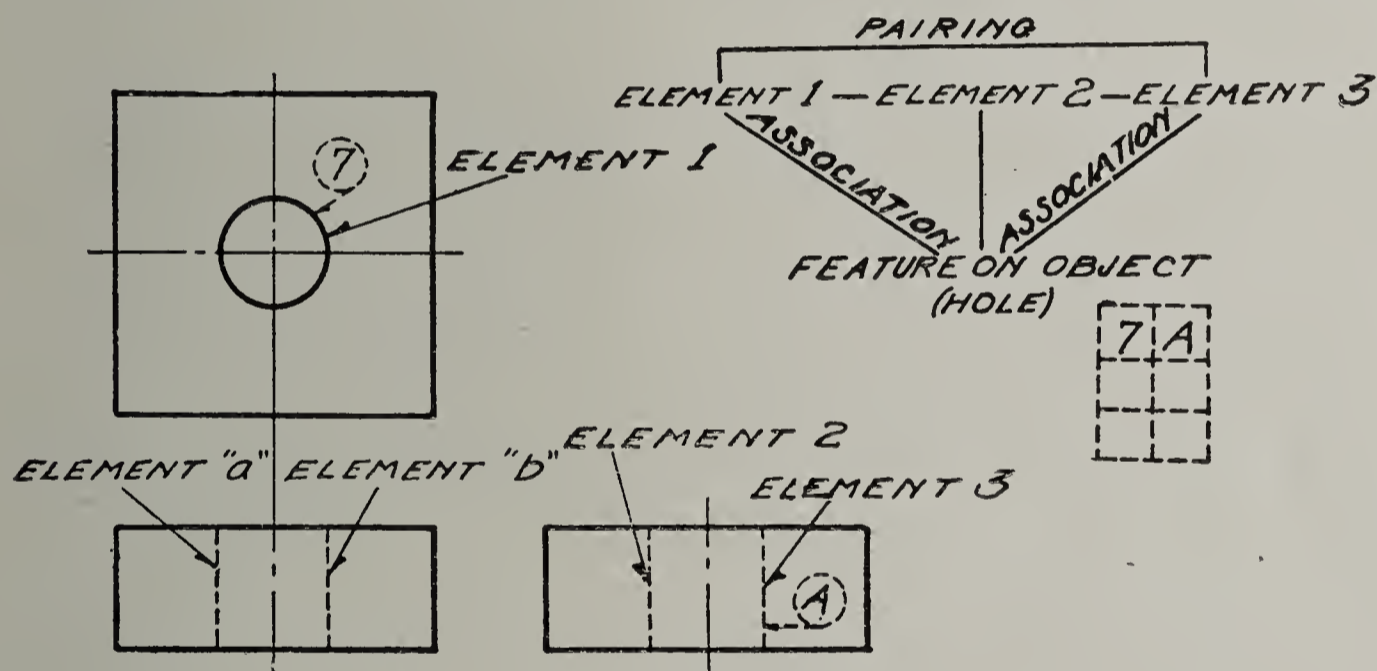


FIG. 2

represent the same feature on the object, does not invalidate the assumption that he has recognized the feature (hole) if he pairs Element 1 with Element 2 by means of the circle device.

The elements in the front and top views or the elements in the front and side views do not lend themselves to the pairing which is required in this test, for the elements in the top view are in general directly above their corresponding elements in the front view, and the elements in the side view

that is, making them so easy in this respect that anyone who had had a slight contact with mechanical drawing could interpret the drawing for the features of the object. Failure to respond correctly to the test, then, could not be the result of an inability to understand the drawings.

The unfortunate adoption of the English system of measurements by the industries of this country makes it imperative that anyone working therein should know quite thoroughly how to deal with the fractional parts

of whole numbers or with devices such as the scale which does some of the computing. It is for this reason that in Part No. 2 stress is placed on problems involving fractions.

PART NO. 3. GEOMETRICAL TERMS

Using the very working elements of geometry and the tools that accurately arrange them into rational forms, as is done in mechanical drawing, results in an unavoidable use of geometrical terms. Since many operations can only be explained in geometrical language, directions are not understandable without the knowledge of geometrical terms. This phase of the subject being purely informational, the test for the ability to understand geometrical terms is thrown into the multiple response and the completion form of examination.

PART NO. 4. PENCIL TECHNIC

In testing the ability of the subject to do pencil drawing, the most intimate related ability that has to be eliminated is drawing interpretation. This has been accomplished by requiring the pupil to copy a drawing that has already been correctly made. Theoretically, any one who has never had instruction in "mechanical drawing," but who has been instructed in the use of the tools in drawing and the technic of lettering, could copy this drawing satisfactorily without having a visual impression of the appearance of the object. Consequently, this device measures only the ability of the subject to perform with the pencil tools in drafting. In order to save time in obtaining the sample of the pencil technic of the subject, a simple object has been selected.

The drawing qualities rated in this part were selected as the most common ones required in commercial practice. The methods of arriving at the qualitative measurements of the qualities are admittedly to some degree subjective. However, by the use of various procedures, this element is reduced to a minimum.

For example, the completion of a drawing, one of the qualities rated, is in a large degree a measure of the speed of drawing and is arrived at by estimating that fraction of the drawing that is finished. "Half done" or "one-fourth done" are common expressions, and to no small degree accurate when experienced persons make the estimates. Such estimates are very easily transferred into measures of points, as required in the weighing of the qualities.

The measure of the legibility of a drawing is quite subjective at best, which, of course, makes the rating that might be given this quality, a rough estimate. It is quite imperative, however, for a drawing to possess this quality, for it must be easy to read. However, the fact that this method of judging this quality is not as objective as it should be, does not overbalance the importance of making some rating in legibility. In making the actual rating, however, as is pointed out in the *Directions for Scoring*, the legibility of the letters must be ignored, for the rating of this quality is covered in a separate item.

The accuracy of a drawing would be very easy to check if the rater measured each line. Such procedure is not practical, neither is it necessary; for, if a few measurements are taken at random, very good samples of the

accuracy of the entire drawing can be obtained. It is important, however, that the rater make an effort to obtain representative samples of accuracy from different parts of the drawing.

The quality of the figures and letters on the pencil drawing are rated by comparing them with samples of other pupils' letters and figures that have been previously rated by experts. (Figs. 4 and 5.) This quality could be rated by the use of a scale already tried out and found effective, such as the Rugg Lettering Scale. It would be necessary, however, to translate the scales used on Rugg's device into a four-point system that is used in this test.

It will be noticed that two separate scales are provided; one for slant lettering, and the other for vertical lettering. Also, that the samples furnished contain the same material that is found in the test. It is obvious that a rating based on the comparison which can be made between a sample and a scale designed in this way will be much more accurate than a rating based on a comparison between a sample and a scale which contains material with foreign subject matter.

There is a "point" in the cleanliness of the drawing which makes the drawing acceptable or not acceptable. If the cleanliness of the drawing is above this point, one score point is allowed. If the drawing is "dirty," this point is not allowed. It is obvious that the method of determining whether or not this point should be allowed for the quality of cleanliness, is not absolute, but since the point value attached to it is small, the final score will be influenced by only a small amount.

PART No. 5. INKING TECHNIC

The rating of inked or traced drawings involves factors quite the same as those found in pencil drawings. Those qualities which are identical in the two situations are **COMPLETE-NESS, FIGURES, and LETTERS.** The comments made above regarding these three qualities have equal application in the case of inked drawings.

The thickness used in the lines of an inked drawing is a matter of standard procedure; made so, because experience has shown that the legibility of a drawing is dependent in a large measure on the rigid adherence to these standards. Thus, the quality of legibility, which is used in the case of pencil drawings, is taken care of in "quality of lines," a rating which is given in the case of inked drawings. The actual assignment of the number of points that should be allowed is a matter of estimate after the lines of the drawing have been scrutinized and compared with the model.

The skill of the draftsman with his pen is very largely determined by his ability to maintain a constant thickness of lines. Negligence in keeping the pen clean or overloading the pen with ink, will invariably show up in the non-uniformity of the lines. The number of points assigned to this quality will of necessity have to be an estimate.

The quality of "neatness" in an inked drawing is an arbitrary name assigned to that condition of the paper relative to blots and erasures. The skill of erasing blots, overruns, and mistakes, shows up quite plainly in rating this quality. A subject is not

penalized, then, if he makes a mistake and corrects it in such a way that it still presents a neat appearance. Here again the assignment of the point score is an estimate, thus making the rating of this quality more subjective than objective.

The comments made above relative to the rating of some of the qualities have been quite critical. Perhaps so much so that the inference is made

that ratings which are not entirely objective are not worth while. It has been proved, however, that ratings based on some organized form of procedure, whereby all raters have clearly in mind the exact nature of the quality rated, are much more accurate and the results more comparable than they are by the ordinary method of grading a drawing or rating a student in mechanical drawing.

DIRECTIONS FOR CONDUCTING THE TEST

EACH student must be seated at a drawing bench with the following equipment:

- 1 Soft pencil
- 1 4H pencil (well sharpened)
- 1 Lettering pen
- 1 Rubber eraser
- 1 Set of drawing instruments (leads well sharpened)
- 1 Tee square
- 1 45° triangle
- 4 Thumb tacks
- 1 Bottle india ink
- 1 Cleaning rag (for pens)

After it has been ascertained that each pupil is ready with the proper equipment in good order, the books will be distributed in the usual way with the warning that they are not to be opened until the signal is given. Proceed then as follows:

“We are now going to determine how proficient you are in mechanical drawing. This test is divided into five parts. You will work on each part for a certain length of time. It will be necessary for you to pay very close attention to directions and do exactly as I say. Prepare yourself now by resting your elbow on the bench with your soft pencil in your hand as I am showing you. We will start each part by the signal ‘go’ and stop upon the signal ‘pencils up,’ at

which time you will assume the position you now have and await further directions. No questions will be answered because all directions will be adequate if you will pay close attention to them.”

FILLING IN INFORMATION BLANKS

“Lower your pencils and fill in the blank spaces at the top of the front page of your booklet with the exception of the one marked ‘Age, Yrs., Mo., and Da.,’ being careful to note the information asked for. Make your writing as plain as you can.”
(*Pause.*)

PART No. 1. (*Allow 3½ min.*)

“Pencils up. In Part 1 of this booklet we are going to interpret some drawings. It will first be necessary for you to read carefully with me the instructions for this part on the front of your booklet.

“ ‘Notice the numbers in the circles on the top view. Notice that these numbers are repeated in the left-hand column of squares. In the circles on the side view are letters. After a careful study of the drawing it will be further noticed that certain numbers on the top view and certain letters on the side view point to the same part of the object.

Place these letters opposite their corresponding numbers in the right-hand column of squares. The top view has one more circle than the side view. Consequently, one circle on the top view has no corresponding circle on the side view. The number in that circle is to have a blank space opposite it in the right-hand column of squares.'

"Following out these directions, then, you will notice upon a study of the drawing below that number one on the top view and letter 'B' on the side view point to the same part of the object. Lower your pencils and write the letter 'B' in the square opposite the number one. (*Pause.*) Upon a further study of the drawing you will readily note that the number two and the letter 'A' point to the same part of the object. Accordingly then write the letter 'A' in the right-hand column of squares opposite the number two. (*Pause.*) Pencils up. You will notice that the number three has no corresponding letter on the side view. Because of this fact the space in the right-hand column of squares opposite the number three will be left empty. In all the problems that follow in the first part, there will be one more circle on the top view than there is on the side view. Therefore, one vacant square should always appear in the right-hand column. Following are three pages of problems similar to this one. When you have finished filling out the squares on one page turn immediately to the next one and proceed in a like manner until all three are completed. Do not turn the fourth page, and remember to put your pencils up immediately when I command you to do so. Turn the first page. Go." (*Allow 3½ min.*)

PART No. 2. (*Allow 4 min.*)

"Pencils up. Close the booklet and turn it over to Part No. 2, which is entitled *Dimensions*. Read with me the directions at the top of the page. 'On the lines below, opposite the equality marks, insert the dimensions asked for.' Here are the front and top views of three objects, and a picture of your scale. You are to write on the lines opposite the equality marks the dimensions called for. In other words, you are to compute the thickness of the walls in No. 1 and write your answer in the space provided. For No. 2, you are to compute the total height of the object; for No. 3 the dimensions X and Y; and for No. 4 the scale reading from *p* to *y* and from *a* to *n*. Do the necessary computation on the test itself. Start when I say 'go,' and work as many as you can. Go." (*Allow 4 min.*)

PART No. 3. (*Allow 1½ min.*)

"Pencils up. Turn the page over to Part No. 3, which is entitled *Geometrical Terms*. You will notice ten sentences which are completed by four words, only one of which is correct. You are to underline the correct word as indicated in the sample at the top of the page: 'Coins are:' The correct word is 'round,' therefore the word 'round' is underlined. The last four sentences have one word missing. You are to write in the missing word. When I say 'go,' you are to proceed and work as many as you can. Go." (*Allow 1½ min.*)

PART No. 4. (*Allow 12 min.*)

"Pencils up. Turn the page over to Part No. 4 entitled *Pencil Technic*, lower your pencil, and fasten the book to your drawing board with thumb

tacks, being careful to line it up with your tee square. (*Pause.*) You are going to copy the drawing of the object in the space on the lower half of the page to see how accurately and neatly you can draw. It will be necessary for you now to place near at hand all of the instruments and equipment necessary for this work. Use your 4H pencil for this drawing. (*Pause—be certain that each subject is prepared.*) Do not forget to put in all of the lettering that belongs to the drawing. Work carefully at your usual rate of speed. Pencils up again. Go.” (*At the end of 10 min. say, “If you have not already done so, start on the lettering.”*) (Allow 12 min.)

PART No. 5. (*Allow 20 min.*)

“Pencils up. Remove the thumb

tacks and turn the page over to Part No. 5 entitled *Inking Technic*. Lower your pencil, line up the drawing of the object with your tee square, and fasten the paper to the board again with thumb tacks. (*Pause.*) Take your instruments and ink the drawing, assuming it to be executed in pencil. Take care to give the lines the proper weight and ink the lettering in your own style. Work carefully at your usual rate of speed. (*Be sure everybody is ready.*) Pencils up again. Go.” (*At the end of 17 min. say, “If you have not already done so, start on the lettering.”*) (Allow 20 min.)

“Pencils up. Allow the ink to dry and close your booklet. That’s all.”

DIRECTIONS FOR SCORING THE TEST

IN Part Nos. 1 to 3, inclusive, 1 point is given for each correct answer. Total the points on each page and indicate the figure at the bottom of the page where a space has been provided.

In Part No. 4 the pencil drawing is scored on the following qualities and weights:

1. Completeness	8 Points
2. Legibility	5
3. Accuracy	4
4. Figures	4
5. Lettering	4
6. Cleanliness	1
Total	<u>26</u>

1. *Completeness* has reference to that fraction which represents how much of the drawing is finished. If the drawing appears to be one-half done this quality should receive 4 points, if it is one-fourth done, 2 points, etc.

2. *Legibility* is the quality pos-

sessed by a drawing that makes it easy to read. The degree of legibility will depend on the time necessary to interpret the lines. The visible outlines should be clean cut and the hidden outlines made up of dashes of approximately equal length. The extension, dimension, and center lines should be a trifle thinner or lighter than the rest. Do not consider the figures and letters in this quality for they are rated under No. 5.

3. A drawing is *accurate* if it measures what its dimensions say it does. To determine this, measure 4 dimensions at random. For every one that is off $\frac{1}{32}$ " reduce the points by 1. Be sure to include at least one circle or curve.

4. *Figures*. Find which one of the accompanying samples (Figs. 4 and 5) most nearly compares with the figures on the test, and rate accordingly.

5. *Letters.* Find which one of the accompanying samples (Figs. 4 and 5) most nearly compares with the lettering on the test, and rate accordingly. If the subject uses slant letters, compare his sample with the slant lettering scale. If the subject uses vertical letters, compare his sample with the vertical lettering scale.

6. *Cleanliness.* If the drawing is not scrupulously clean, do not allow this point.

In Part No. 5 the inked drawing is scored on the following qualities and weights:

1. Completeness	8 Points
2. Quality of lines.....	5
3. Uniformity of thickness.	4
4. Neatness	3
5. Figures	3
6. Letters	3
<hr/>	
Total	26

1. *Completeness* has reference to that fraction which represents how much of the drawing is finished. If

VISIBLE OUTLINE
HIDDEN OUTLINE
SECTION LINE
DIMENSION LINE
EXTENSION LINE
CENTER LINE

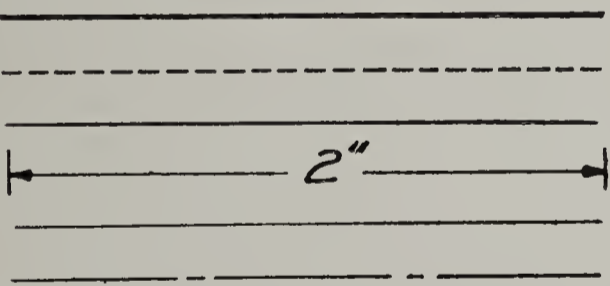


FIG. 3

the drawing appears to be one-half done, this quality should receive 4 points; if it is one-fourth done, 2 points, etc.

2. *Quality of lines.* The generally accepted standard thickness for the various lines is given in Fig. 3.

Conformity with the above standards, smoothness of curve, and straight-line intersections, uniformity of distance between section lines, uniformity of length of dashes in hidden

outlines, and quality of arrowheads should be considered in this score. Do not consider the figures and letters in this quality.

3. *Uniformity of thickness.* This quality has reference to the uniformity of thickness of the inked lines. The following questions should be asked: Are all visible outlines of the same thickness; are all center lines of the same thickness, etc.?

4. *Neatness.* This quality is general but should exclude figures and letters. Any blots, erasures, over-running lines, and general cleanliness should be considered.

5. *Figures.* Find which one of the accompanying samples (Figs. 4 and 5) most nearly compares with the figures on the test, and rate accordingly. If the subject uses slant letters, compare his sample with the slant lettering scale. If the subject uses vertical letters, compare his sample with the vertical lettering scale.

6. *Letters.* Find which one of the accompanying samples (Figs. 4 and 5) most nearly compares with the lettering on the test, and rate accordingly.

The possible scores are:

Part Nos.

1. Interpretation by Features.	28
2. Dimensions	6
3. Geometrical Terms.....	14
4. Pencil Technic.....	26
5. Inking Technic.....	26
<hr/>	
Total	100

SLANT
LETTER RATING SCALE

SECTION A-A
FINISH ALL OVER

SECTION A-A
FINISH ALL OVER

SECTION A-A
THIS GROOVE TO BE
FILE FINISH

SECTION A-A
THIS GROOVE TO BE
FILE FINISH

1234567890
RATE 4

1234567890
RATE 3

SECTION A-A
FINISH ALL OVER

SECTION A-A
FINISH ALL OVER

SECTION A-A
THIS GROOVE TO BE
FILE FINISH

SECTION A-A
THIS GROOVE TO BE
FILE FINISH

1234567890
RATE 2

1234567890
RATE 1

FIG. 4

VERTICAL
LETTER RATING SCALE

SECTION A-A
FINISH ALL OVER

SECTION A-A
FINISH ALL OVER

SECTION A-A
THIS GROOVE TO BE
FILE FINISH

SECTION A-A
THIS GROOVE TO BE
FILE FINISH

1234567890
RATE 4

1234567890
RATE 3

SECTION A A
FINISH ALL OVER

SECTION A-A
FINISH ALL OVER

SECTION A A
THIS GROOVE TO BE
FILE FINISH

SECTION A-A
THIS GROOVE TO BE
FILE FINISH

1234567890
RATE 2

1234567890
RATE 1

FIG. 5

